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ROCKY MOUNTAIN SPOTTED FEVER, TULAREMIA, AND RODENT PLAGUE*

BRIEF DISCUSSION OF THESE SPECIFIC DISEASES IN THEIR BEARING ON PUBLIC HEALTH IN WESTERN STATES

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THE particular diseases of Rocky Mountain spotted fever, tularemia, and rodent plague have been selected for brief discussion. Each is a disease occurring primarily or principally in the Western states, and one, plague in ground squirrels, exists only in one state.

These three diseases have a direct bearing on the public health of the communities in which they are found. The purpose of this paper will be to stress this phase and give only such general data as may be necessary for a connected and intelligent presentation of the subject.

ROCKY MOUNTAIN SPOTTED FEVER

The first of these diseases to be considered is Rocky Mountain spotted fever, because it constitutes a definite public health problem in at least three Western states.

Historical.—Although this disease has been known in Idaho and Montana since 1873, it was not until 1899 that it began to attract marked attention—after the presentation of a paper by Dr. C. E. Maxey of Boise, Idaho.

Rocky Mountain spotted fever has long been a blight on the Bitter Root Valley in Montana, where the most virulent type occurs, and the Montana State Board of Health since 1902 has been actively engaged in trying to solve the problem of transmission and prevention of this disease. That board sought outside aid and secured the services of Doctors L. B. Willson and W. M. Chowning, who carried out the first serious laboratory study of the disease. They suggested, in their report of 1902, the rôle of the ground squirrel (*Citellus Columbianus*) and the tick (*Dermacentor Andersoni*) as host and transmitter, respectively.

Following these investigations came others by Ashburn, Craig and Keiffer of the Army, and several officers of the United States Public Health Service (one of whom was McClintic, who contracted the disease and died). The most noteworthy among these early investigators are the martyred Rickerts and his associates. They demonstrated: that infected ticks exist in nature and that by their bites the disease could be reproduced in guinea-pigs; that ticks infected by feeding on infected animals may transmit the infection to healthy susceptible animals; and that infected female ticks transmit the disease to their young through their eggs.

Geographical Distribution.—Since the disease exists in ticks (*Dermacentor Andersoni*) in nature, Rocky Mountain spotted fever may occur in any areas where the dermacentor is found. However, this need not be a general distribution, but only in some specific portion of such an area; as the disease exists in definite foci, and the virulence of infection may vary decidedly even in adjacent areas.

The infested regions include the northern part of the Rocky Mountain region in the United States, and the river valleys and sagebrush plains to the west, namely, western portion of North Dakota and South Dakota, almost the entire state of Idaho, Montana, Wyoming and Colorado, the northern portion of New Mexico, Utah and Nevada, eastern half of Washington and Oregon, and the northeastern corner of California.

Laboratory Investigations.—Spencer and Parker of the United States Public Health Service, who were detailed to work with state health authorities, in recent years have secured some valuable data regarding the infectivity of ticks and the action of the virus under different conditions.

These investigators found that the virus of spotted fever survives in the tissue of infected ticks through extremely cold weather, but that the virus was apparently attenuated. Experiments were carried out with so-called drag ticks, which are unfed, wintered ticks in nature, and also with ticks infected in the laboratory and placed outdoors for the winter months.

It was established that when guinea-pigs were inoculated with these ticks, spotted fever was not produced, but an immunity was conferred in a large percentage of the guinea-pigs. However, when other wintered ticks of the same lot were incubated for two days, or were allowed to feed on animals for forty-eight hours, they produced the fever when fed on or inoculated into guinea-pigs.

In this connection it may be stated that animals are considered immune when spotted fever does not develop, following an injection of one cubic centimeter of citrated heart's blood of a guinea-

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pig at the height of the infection, but does develop in control animals.

The following table, taken from a report by Spencer and Parker, showing the result of tests with these (drag) ticks proves of interest:

Drag Ticks Infectivity Tests

(a) By direct inoculation:	
Total tests completed	101
Tests resulting in spotted fever	0
Tests resulting in immunity	29
Tests negative	72
(b) By combined feeding and inoculation (including tests in which the pig sickened with spotted fever after feeding alone, inoculation therefore being omitted):	
Total tests completed	65
Tests resulting in spotted fever after feeding	10
Tests resulting in spotted fever after inoculation, ticks having previously fed	10
Tests showing immunity from feeding and inoculation	8
Tests negative from feeding and inoculation	37

The foregoing is particularly interesting in showing that infected, unfed, wintered ticks produce immunity, and that in order to convey the fever, reactivation of the virus either by incubation of ticks or feeding is necessary. The factors operative in increasing the virulence are not clearly known. However, the feeding in the majority of instances must be from ten to forty-eight hours. This need for prolonged feeding may furnish an explanation of the comparatively small number of human cases which occur in even badly infected locations, as no doubt many ticks that attach themselves to man are removed before reactivation has taken place.

It was also noted that virus of infected ticks to which 0.5 per cent of phenol was added, when injected into guinea-pigs, did not produce spotted fever, but did bring about relative degrees of immunity.

Taking cognizance of these facts, Spencer and Parker have prepared a vaccine from infected ticks; and its protective value having been demonstrated in guinea-pigs, rabbits and monkeys, its use has been extended to man.

Relation to Public Health in the Community.—Spotted fever has long constituted a public health problem in Montana and Idaho and may become so in other territory where infection exists, with the occurrence of occasional human cases.

A large number of small rodents, particularly ground squirrels (*Citellus Columbianus*) chipmunks, rock squirrels and woodchucks, are susceptible, and these animals constitute a permanent reservoir of infection in districts where the disease exists. However, there is no evidence that the infection is highly fatal among them. Ticks (*Dermacentor Andersoni*) perpetuate the infection by feeding on these rodents; carry the infection throughout their life cycle, and transmit it through their eggs to the next generation.

When consideration is given to these facts the stupendous task that has confronted health authorities can be visualized. Until recently the preventive measures have been directed against these small rodents and ticks through such procedures as clearing away brush, burning over the area, destruction of small rodents, dipping of domestic animals and sheep grazing. These methods have produced no appreciable reduction of human cases; in fact, such measures can never be effective on account of the large areas where infection exists and of the prohibitive cost of such undertakings.

Vaccination.—The control of this disease can probably be effected if a protective vaccine in sufficient quantity becomes available for the vaccination of those persons, who from their occupation, must expose themselves in infected areas. The following statistics available from use of a vaccine prepared by Spencer and Parker are interesting.

In 1925 thirty-four persons were vaccinated, chiefly laboratory employees and field workers whose duties constantly exposed them to infection, and only one case of spotted fever, milder in type, developed, the patient going on to recovery.

In 1926 and 1927 some 1872 persons living in Bitter Root Valley, where the most virulent type exists, were vaccinated, and no case of fever occurred among them. In a nonvaccinated group, fourteen cases occurred, with twelve deaths. In 1927, among a group of 319 sheep herders in Idaho, 115 were vaccinated. There were nine cases among the nonvaccinated and two among the vaccinated (both of whom recovered). In 1926, in the same group, thirteen cases occurred among the 221 not vaccinated, and no case among the ninety-four vaccinated.

In a group of 300 nonimmune sheep herders in Wyoming ninety-five were vaccinated, with no outbreak of the disease, whereas there were seven cases of spotted fever among the nonvaccinated.

Comment.—While these statistics are small and the results obtained should not be interpreted as conclusive evidence, they are at the same time highly suggestive that a protective measure has been found against this disease. Furthermore five mild infections, with prompt recovery, have occurred in laboratory workers who had been vaccinated, whereas previous to the use of vaccine the five laboratory infections which occurred were fatal. This indicates that in event absolute protection is not afforded, the virulence of the infection is modified to the extent that cases developing are mild in type.

TULAREMIA

Tularemia should be of sufficient interest to the physicians of California to justify its mention before this association, because the causative micro-organism was first discovered in California, and the name Tularemia has been derived from Tulare County, in this state.

Historical.—McCoy and Chapin discovered the micro-organism of the disease in 1911, in ground squirrels from Tulare County, California, while making routine examination of ground squirrels from several counties, to determine if bubonic plague infection existed among them. Some of these animals presented gross pathological lesions resembling to some extent those of plague, but

animal inoculations and bacteriological examinations proved this was a new infection, and for want of a better name they called it "Plague-like Disease." Since that time the disease has been found in ground squirrels in several other localities.

Francis in his investigation of "Deer-Fly Fever" in Utah (1919), found that the micro-organism isolated from human cases, through inoculation of guinea-pigs with blood from patients, was identical with that previously described by McCoy.

Taking cognizance of the fact that this disease in rodents was first found in those from Tulare County, Francis named the disease tularemia and the causative micro-organism *Bacterium tularense.*

Distribution in Nature.—(1) Ground squirrels; (2) wild rabbits and hares; (3) wild rats; and (4) wild mice, have been found infected with *Bacterium tularense.*

While tularemia has been found in all the rodents specified, the wild rabbits and hares constitute the great reservoir of infection. Wherry and Lamb isolated *Bacterium tularense* from cottontail rabbits found dead in southern Indiana. Francis cultured tularense from guinea-pigs which had been inoculated with the spleens of seventeen jack rabbits shot or found dead in Utah, the spleen of a snowshoe rabbit found sick in Montana, and the livers of ten cottontail rabbits bought in the Washington, D. C., market. Numerous observers have reported sick and dead rabbits in communities where human cases of tularemia were occurring.

Dieter and Rhodes in 1925 cultured three strains of *Bacterium tularense* from guinea-pigs which had been inoculated with tissues of rats which had been trapped in the city of Los Angeles. These observers were engaged at the time in examining rats for plague.

The writer of this article (Perry), in September, 1927, isolated *Bacterium tularense* from wild meadow mice (*Microtus Californicus Aestuariensis*) by guinea-pig inoculation. These mice were obtained from a locality in Contra Costa County, California, where an epidemic disease affecting mice was prevailing. Large numbers of sick and dead mice were noted. A recheck over this and adjacent areas where infestation had been heavy, showed very few mice remaining, so that it may be safely inferred that the tularemia outbreak among the mice caused a large mortality. This is the first and only record of the infection having been found in wild mice.

While tularemia first attracted attention in the Western states, particularly Utah, as "deer fly fever," the disease is now found widely scattered and has been reported in thirty-nine states and the District of Columbia, as well as in Japan. The nine states from which cases of tularemia have not been reported are Maine, New Hampshire, Vermont, Connecticut, Massachusetts, Rhode Island, Delaware, Wisconsin, and Washington.

Mode of Transmission.—Tularemia is transmitted to animals by blood-sucking insects: lice, flies, and ticks. The last may be considered as a permanent reservoir of infection. They carry the infection over winter, harbor it throughout life and transmit it to the next generation through their eggs.

Transmission to man from animals occurs: (1) by bite of the horsefly (*Chrysops discalis*): (2) by bite of the wood tick; and (3) by contamination of hands or conjunctival sac with portions of the internal organs or with the body fluids of infected rabbits, ticks or flies.

Any of the above agents may be operative, but most of the human cases of tularemia are caused by the specific acts of the individuals by which they inoculate themselves.

In connection with the foregoing the following is taken from an analysis in a recent article, made by Francis, concerning the source of infection in 292 human cases. That analysis showed that 23 of the patients had been fly-bitten, 44 had been tick-bitten, and 225 had dissected or dressed rabbits.

Occupation.—The largest number of cases occur among farmers and their families; the second group in frequency are market men, housewives, and cooks; hunters occupy third place; and laboratory workers constitute a large group.

It is not the purpose of this article to discuss tularemia fully, but only to present such salient points as should be taken into consideration from a public health standpoint. Therefore types of the disease, symptoms, diagnosis, including bacteriology and pathology will be omitted.

Let it suffice to say that physicians who bear in mind the following tetrad will seldom fail to correctly diagnose the disease: (1) A history of having dressed or dissected a wild rabbit or of having been fly or tick-bitten. (2) A primary lesion of the skin in form of a papule followed by a persistent ulcer, or a primary conjunctivitis followed by an ulcer of the conjunctiva. (3) A persistent enlargement in the lymphatic glands draining the region of the ulcer. (4) A fever of two or three weeks' duration.

Relation to Public Health of the Community.—When consideration is given to the fact that only a few human cases of tularemia have been reported in California, although there is infection in wild rabbits, ground squirrels and wild mice, it seems evident that tularemia does not constitute a public health problem in this state. In other localities, particularly Utah and Montana, specific areas may demand the attention of health officers in rural communities. Tularemia is certainly of economic importance because farmers become infected at a season when their labors are most required, and when the disease is acquired the person afflicted is incapacitated for months on account of the slow convalescence.

No protective vaccine has been perfected. The weapon of defense is education, and district health officers can render valuable service by presenting to physicians and to the public the facts concerning the disease, and the means by which it is contracted. Simple precautions are all that are necessary; such as wearing rubber gloves when dressing or handling suspected animals, avoidance of soiling hands with body fluids of rabbits, ticks,

and flies, and prevention of bites from flies and ticks in regions in which sickness is occurring among wild rodents.

PLAGUE IN GROUND SQUIRRELS IN CALIFORNIA

Of particular interest to health officials in California is the existence of plague in ground squirrels over a large area in the state. This constitutes the only focus of plague in the United States, and under the present scheme of operations it will remain indefinitely as a potential source of danger and a grave menace to the community in which it exists.

Plague in ground squirrels was first bacteriologically proven in 1908, but investigations carried out at that time showed that the disease existed in these rodents prior to the date of determination; and, furthermore, reports indicated that ground squirrels in the East Bay counties died from some epizoötic as early as 1900.

A campaign was started in Alameda and Contra Costa counties in the spring of 1909 by the Public Health Service, working in coöperation with state and local authorities, for the purpose of determining: (*a*) the extent of infection, and (*b*) the eradication of determined foci of infection by intensive poisoning operations against the squirrels. This work was extended to include the following ten counties: Alameda, Contra Costa, Merced, Monterey, San Benito, San Joaquin, Santa Clara, Santa Cruz, San Mateo, and Stanislaus, and was continued until 1917. Plague foci in ground squirrels were proven in all these counties.

In 1920 it was possible to carry out collection and examination of squirrels in seven of these original counties, and plague infection was found in each.

Present Conditions.—Plague undoubtedly exists in ground squirrels over a wide area, and because the work it was possible to accomplish from 1909 to 1917 under large appropriations, and when the danger was fresh in the minds of the people, did not eradicate but only controlled the disease, the future outlook is not bright.

In 1921 there were two human cases of plague in San Benito County, and plague squirrels were demonstrated in 1926. Both human and rodent plague was found in Alameda and Santa Cruz counties in 1922, and one human case was contracted in Monterey County in 1923.

In 1924 there occurred an exacerbation of plague in ground squirrels and there was unusual mortality in squirrels in San Benito and Monterey counties and a virulent outbreak of rodent plague in San Luis Obispo County. In October and November of 1924, a violent form of pneumonic plague was discovered in Los Angeles.

Shooting operations were carried out by the California State Department of Health in 1927, although only two hunters were employed and the number of squirrels shot and examined was relatively small. Plague foci in ground squirrels were shown to exist in Contra Costa, Santa Cruz, and Monterey counties. If sufficient appropriations had been available for placing on duty a large number of hunters, it is believed plague would have been demonstrated to be present in other counties.

In 1927 one human case of plague occurred in Contra Costa County and another case occurred in February, 1928, from handling infected squirrels trapped within the city limits of Santa Cruz.

Incidence of Infection.—As in rats, the percentage of infected squirrels to the total is low, but in proven foci of infection it may be high, as will be later shown for San Luis Obispo County in 1924.

In 1902 a total of 19,507 squirrels were examined in the laboratory, and 108 were found plague-infected. This gives a percentage of infection of .55. This indicates results of general shooting operations over large areas to determine foci of infection.

Operations around infected centers yield a much higher incidence, and the following are cited in illustration: 407 squirrels obtained within a radius of two miles around a focus in Contra Costa County showed 2 per cent infected; the examination of 259 squirrels shot within a radius of one mile of a center where a human case occurred, gave 3.5 per cent infected; in San Luis Obispo County the examination of a limited number of squirrels shot at a point where four dead squirrels had been picked up and proven positive yielded the enormously high percentage of 19.

The incidence of infection in the ground squirrels shot and examined by the State Department of Health in 1927 was .47.

Existing Danger.—As long as there are foci of plague infection there is danger to the communities in which they exist and to other places by extension of infection from those foci.

The gravest danger is that of rural plague becoming urban, through the transmission of plague to the rats of populated centers from the ground squirrels in the same environment. These rodents come together in the outskirts of towns and have been caught from the same burrow.

A second danger is that of human plague from contact with infected squirrels. A number of such cases have occurred, and nearly every year there are one or more victims. While in the majority of such instances there has not been any spread of the disease from the affected individual, it is not safe to assume that this will be the result, since such human cases may be the starting point of a serious outbreak, as evidenced by the occurrence of fourteen cases of pneumonic plague in Oakland during 1919, and of some thirty-two cases of pneumonic plague in the Los Angeles outbreak in 1924.

From the nature of the outbreak of plague in Los Angeles, which was mainly pneumonic, the type generally transmitted by marmots, and the determination of plague-infected squirrels within the city limits in the areas adjacent to where the human cases occurred, it is quite probable that the infection in that city had its origin in infected

ground squirrels transmitting plague infection to rats.

Remedial Measures.—These measures can be discussed under (*a*) eradicative measures and (*b*) control measures.

If it were possible to exterminate the ground squirrels the plague infection would be eradicated. However, when thought is given to the degree of infestation it will be realized that the extermination of these rodents is an impossible task. Certainly under the procedures now being carried on, the extermination of squirrels or the eradication of plague infection in them will not be accomplished.

The only method of eradication of plague among squirrels that appears to the writer, is an intensive shooting campaign over large areas for the purpose of determining foci of infection, and then intensive work for the extermination of the squirrels at and around these foci of infection. Such a campaign would be expensive and necessitate much larger appropriations than are now being made, but such expenditures, even if large, would be economy in the end and would accomplish results impossible to obtain under past or present procedures. Under this plan it is believed that plague infection could be eradicated. The destruction of squirrels in noninfected areas would resolve itself into an economic problem.

The State Department of Health is the logical agency to carry out these operations, and sufficient appropriations should be allowed that organization to permit of an extensive shooting campaign to determine foci or plague among ground squirrels. A start in that direction was made last year, and it is understood that a similar campaign will be carried out this year. However, sufficient funds should be made available to enable the prosecution of intensive work.

After the determination of foci or plague infection it might be possible, through the Horticultural Commissioners of the counties, to have enacted intensive eradicative measures around such determined foci.

If the ideal is unobtainable, what control measures can be employed to effect a reasonable degree of safety? This objective can be obtained by local intensive operations for the purpose of bringing about squirrel-free zones around centers of population, especially around the cities. Furthermore, this measure should be carried out around towns, villages, schoolhouses, and rural dwellings. The work carried out at the present time is localized control and not eradicative.

Plague in Urban Communities.—This discussion would be incomplete without some reference to plague in cities and towns, as remedial measures which are different from those employed against ground squirrels would have to be directed against rats.

It is of paramount importance in cities infected or that have been infected with plague to institute those measures which experience has taught are essential either in the eradication of plague, or for placing such communities in a sanitary condition from a plague standpoint that would render them less infectible, and to facilitate the eradication of the disease if lodgement should occur.

The only efficient measure is the rat-proofing of buildings and the destruction of rat harborages. This cannot be too strongly emphasized, and all seaport cities should have such ordinances in effect; and, furthermore, these ordinances should be rigorously enforced by the health departments of such communities.

Cities that have been infected with plague must be regarded as liable to reinfection unless proper rat-proofing of buildings has been carried out.

The second measure that should be practiced in cities that have been infected with plague is a continuous rat survey, and this should be sufficiently extensive to give a fair cross-section of the rodent population. This will prove of marked value from both a public health and economic standpoint. It would give early information of any foci of infection and permit of prompt eradication before the disease had spread. The economy that would result from this practice can be easily visualized.

The task is stupendous, but as the work prosecuted against ground squirrels, with varying degrees of intensity for nineteen years, has not eradicated the infection in many of the counties in which it has been proven, it seems imperative that more vigorous action should be taken to eliminate this potential danger.

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EMOTIONAL INFLUENCE UPON THE GASTRO-INTESTINAL TRACT*

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EVIDENCE of the close connection between the nervous system and the gastro-intestinal tract is always before us. Sinking feelings upon the receipt of bad news; the sudden epigastric cramp just before an automobile accident, and the often quoted relaxation of sphincters at moments of great fear are known to everyone. The organic changes associated with these states have not been demonstrated roentgenologically. But the intestine is equally responsive to emotional stimuli of lesser degree, and the signs of their presence are constantly before us upon the fluoroscopic screen.

CONFIRMATORY HISTORIES

The chairman's address before the medical section of the American Medical Association last year dealt with this subject, and he mentioned the following case:

An apparently normal business man developed an obstruction in his sigmoid during an emotional crisis where he had to sacrifice either his principles or his position. Opaque enema showed a complete block, and the patient only escaped

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